COMMITTEE ON AIR POLLUTION

Interim Report

Presented to Parliament by the Minister of Housing and Local Government, the Secretary of State for Scotland and the Minister of Fuel and Power by Command of Her Majesty
December 1953

LONDON
HER MAJESTY'S STATIONERY OFFICE
Reprinted 1959

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Secretary:—Miss R. Cave, Ministry of Housing and Local Government.

The estimated cost of the Committee up to the date of publication of this Report amounts to £220, of which £170 represents the estimated cost of the printing and publication.

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To The Rt. Hon. Harold Macmillan, M.P.,
Minister of Housing and Local Government.

The Rt. Hon. James Stuart, M.P.,
Secretary of State for Scotland.

The Rt. Hon. Geoffrey Lloyd, M.P.,
Minister of Fuel and Power.

We were appointed by you on the 21st July, 1953, with the following terms of reference—

> "To examine the nature, causes and effects of air pollution and the efficacy of present preventive measures; to consider what further preventive measures are practicable; and to make recommendations."

The problem of air pollution is one of outstanding importance; it is of vital consequence to human health, it has far-reaching social effects and it has material economic consequences. It is also a problem of great complexity. To deal fully with all the factors so as to make positive recommendations will inevitably take time. But that does not prevent ameliorative action being taken effectively and progressively stage by stage. To that end, and in order to put the whole matter into proper perspective we think it desirable to submit an interim report forthwith on this first stage of our enquiry. We have the honour to do so herewith.

On behalf of the Committee,

HUGH BEAVER,
(Chairman).

18*th November,* 1953.

INTRODUCTION

1. Air pollution in this country comes from many sources and takes many forms. It includes not only smoke, gases, dust and grit from chimneys, smoke from locomotives and ships, exhaust gases from internal combustion engines, but also the fumes, gases and products of chemical works and industrial processes, and airborne dust from other sources. Although our terms of reference are wide enough to cover all these aspects of the problem *we have decided to concentrate in the first place on air pollution arising from the combustion of fuels,* as being the main cause of "smog"* of the kind which did so much damage in London in December, 1952, and which is a recurring evil in many large towns. We shall start by dealing primarily with visible pollution, i.e. smoke and grit.

2. The problem of air pollution, and in particular smoke, has been the subject of much study and research and a large volume of technical knowledge is available on the subject. Preventive legislation dates back to the middle of the nineteenth century, and in addition to the work of public authorities, various other bodies, notably the National Smoke Abatement Society, have long been active in publicising the evils of pollution and promoting measures of abatement. We do not propose, therefore, as a Committee to embark on any long and detailed programme of research, although we shall have recommendations to make about the directions in which further research must be pursued. The task as it appears to us is first to take stock of the considerable volume of facts at present known about air pollution—its nature, causes, effects, and the methods of prevention ; and on the basis of these known facts to consider, having regard to all the technical, social and economic implications, what effective preventive measures can be taken immediately, and what more is needed either by legislative or administrative action, by education, or by other means.

3. This Interim Report is divided into two parts. Part One (paras. 4–17) summarises the facts of the problem, as we see them at this stage, and includes some recommendations as to immediate measures that might be taken. Part Two (paras. 18–81) is a more detailed and more technical survey of the problem of air pollution arising from the combustion of fuels, including oil and oil products, as it exists at present. The size and complexity of the field of enquiry are indicated and the measures of amelioration or of control already in existence are described. We hope by this means not only to give a broad but balanced and accurate picture of the subject as a whole ; but particularly to identify, and focus attention on, the crucial factors upon which we shall require evidence before making our final recommendations.

* The word "smog" is used to connote a combination of natural fog and solid and gaseous polluting substances.

PART ONE

OUTLINE OF THE PROBLEM AND RECOMMENDATIONS FOR IMMEDIATE ACTION

THE PROBLEM OF AIR POLLUTION

4. Sufficient is known already about the causes, effects and cure of air pollution to enable the broad problem to be appreciated, measured and largely tackled.

The main sources of air pollution are smoke from the incomplete combustion of fuel and oxides of sulphur formed by combustion, whether complete or incomplete, of the sulphur present in nearly all fuels. A subsidiary source is the fine dust and grit derived from the combustion of fuel.

Medical experience leaves no doubt that whilst the clean white fogs consisting only of water droplets to which this sea-girt island is inevitably prone may have uncomfortable effects on people in certain states of health, the harmful and dangerous "smog" occurs only when smoke and oxides of sulphur and perhaps other deleterious substances are present in the fog in quantity. Health suffers wherever smoke is prevalent even in the absence of fog or mist, but it is their combination that does real harm.

On the material side we know that vast damage to metals and building materials results from the corrosive sulphur acids, mainly sulphuric acid, formed from the sulphur in fuels.

The detrimental effect of smoke and oxides of sulphur on vegetation is common knowledge.

5. Both medical opinion and chemical investigation indicate that the deleterious effects of the oxides of sulphur are greatly enhanced by the presence of smoke particles and our conclusion therefore is that *the first objective should be to prevent the emission of coal smoke and oil smoke,* and of grit. By smoke we mean solid particles of soot, fine dust and minute liquid droplets of tar and oil.

6. Smoke is discharged from domestic chimneys and from industrial chimneys; obviously the greater the concentration of buildings the greater the pollution. An estimate put before us by authorities on this subject indicates that over the country as a whole rather less than half the smoke is derived from the domestic chimney, about the same quantity from industry including public utility undertakings and road transport, and the remainder from coal fired locomotives and other sources. But these proportions will vary considerably according to season, and whether a district is primarily industrial or residential; and it has been estimated that in the London "Smog" of December, 1952, up to 60 per cent. of the smoke was due to domestic fires.

7. It follows that a first, immediate and stubborn obstacle to the reduction of smoke is the preference of the majority of people for traditional methods of heating. The need for education and training in these matters is urgent and vital.

Industrial Smoke

8. The elimination of industrial smoke is intimately connected with the efficient use of fuel. With few, if any, exceptions, no industrial chimney need emit more than a light haze of smoke if the combustion arrangements are

adequate and are properly operated. To achieve this will in many cases involve replacing or modifying existing equipment, and will involve capital expenditure ; but it is completely possible.

9. Whatever the equipment, much can be done by training stokers and it may be for consideration whether any other than trained men should operate boilers and furnaces.

10. Full remedial measures will take time. There is no quick and easy way to remove all smoke from the atmosphere within the next year or two. There has been action over the last 50 years, but progress has been inadequate ; and far more can be done by firmly tackling the problem of burning industrial fuel efficiently. We shall investigate further both the powers that exist to control the emission of smoke and the means that are available to ensure the installation of efficient plant to burn coal and oil.

11. As we have indicated, the prevention of the emission of smoke is our immediate concern, but we are well aware that the serious problem of sulphur oxides and other polluting agents will remain, and this is having our consideration.

Domestic Smoke

12. Domestic smoke, being discharged at low temperature and at a low level, and principally arising during seasons when fog is normally prevalent, has in densely populated areas the greatest effect in forming " smog ". In residential districts in which many houses are closely packed together a haze of smoke will generally hang over the district at all times except in windy weather. This at its worst turns into obnoxious and dangerous " smog " in large towns under atmospheric conditions described later (para. 23) in this report ; but in any event it has the effect of reducing sunlight, inducing fogs, causing dirt and corrosion, and consequent deterioration of the whole neighbourhood.

13. The prevention of domestic smoke is theoretically simple but involves practical difficulties which we are now investigating. It is relevant to point out that:—

(1) The householder himself creates much, and in some areas nearly all, of the smoke that causes damage to his own property, expense and heavy work in washing dirty fabrics, and ill-health to his family.

(2) The vast majority of domestic space heating grates, especially in the industrial areas of the country where the smoke problem is most acute, are of old-fashioned design, made for the specific purpose of burning coal. Most smokeless fuels, other than low temperature coke, cannot be burnt satisfactorily in these appliances. It is a major problem to replace the millions of these inadequate grates now in use by grates of suitable design.

(3) The *complete* prevention of domestic smoke in the present state of our knowledge, rests on the use of smokeless fuels in all domestic appliances. The problem, here, is how to provide the quantity and quality of smokeless fuels necessary at a reasonable price and to secure that householders use them. The plain and inescapable fact is that there is nothing like enough smokeless fuel in the country for this purpose either now or in sight within the next few years. Although the Simon Committee in 1946* recommended that measures be taken forthwith to provide the necessary fuels within a period of years, little or nothing on the lines there envisaged

* Report on Domestic Fuel Policy by the Fuel and Power Advisory Council, 1946. Cmd. 6762.

seems to have been done. Provision of smokeless fuel for the whole country on the scale indicated would inevitably be a long-term objective, but, we believe, it should be possible to provide within only a few years sufficient smokeless fuel to supply all the worst areas. But this involves problems both of supply and of economics, into which we are enquiring. We are at the same time examining whether there are possibilities of *material* reduction in smoke emission by developing and using domestic appliances to burn bituminous coal smokelessly.

Transport

14. Smoke from railway engines and the exhausts of motor vehicles add seriously to pollution in densely populated areas; and in ports and busy rivers shipping creates considerable amounts of smoke. Much of the pollution from these sources is preventable. We are enquiring into the measures which now exist or may be required, to prevent or reduce such pollution.

RECOMMENDATIONS FOR IMMEDIATE ACTION

15. As a matter of immediate concern, we have given consideration to what precautions might be taken to avoid during the coming winters the worst effects of "smog." No measures that will materially change the present position can be put into effect at short notice. But it is possible to procure some reduction of the amount of smoke that is discharged into the atmosphere. That is a matter for everyone who uses or controls the use of fuels. It is a matter in regard to which everyone has both a duty and an opportunity.

(1) **The Authorities**

(*a*) Arrangements should be made as soon as possible for the Meteorological Office to issue a warning by appropriate channels, and in particular the B.B.C., of areas of normally high pollution in which serious fog is expected to obtain for at least 24 hours.

(*b*) Every effort should be made without delay (1) to provide adequate supplies of smokeless fuels to domestic consumers in London and other densely populated areas liable to bad fog during the winter; and (2) to inform such domestic consumers when such supplies are available so that they may, at least, lay in a small stock for use when fog is developing.

(*c*) The appropriate authorities should, by whatever means are most suitable, bring to the notice of the public resident in areas liable to "smog" the fact that the largest single producer of smoke is the domestic consumer, and that it is to the personal advantage of everyone to co-operate in taking all practicable steps to reduce the amount of smoke discharged into the atmosphere.

(*d*) Steps should be taken to secure fuller and more frequent measurements of pollution, especially during severe "smogs", in order to determine the peak concentrations reached. This will greatly assist our further investigation. Local authorities can do most valuable service in this respect.

(2) **Industry**

Smoke control measures in industry, shops, offices, hotels, etc., should be brought up to peak efficiency at the beginning of the winter and their performance checked at frequent intervals throughout the winter. Special efforts should be made, even when equipment is old fashioned or inefficient, to prevent heavy smoke emission when stoking. Much of the smoke from

factory furnaces whatever their nature can be prevented, and industrial management should accept at all times and particularly under foggy conditions, the responsibility of ensuring that no substantial amount of smoke is emitted.

Managers of industrial plants, public utility undertakings, and establishments such as hospitals, institutions, offices and laundries, should institute a special continuous check to ensure that dark smoke is not emitted from their chimneys either by night or by day, and particularly during the early morning before daybreak. This check can best be made by the installation of a simple smoke density indicator. There are several proprietary instruments on the market, but even a simple home-made device is helpful. Sketches of two types that can be made up by most small works for a few pounds are given in Appendices II and III.

(3) **The Householder**

Householders in large towns who are dependent on solid fuel and who normally burn coal should, before each winter, lay in a stock of, say, 1 cwt., of coke or other smokeless fuel for use during periods of persistent fog. A mixture of coke and coal will burn reasonably well and will greatly reduce smoke.

(4) **Instructions to the general public when persistent fog is forecast**

Householders who can use only coal should take special care not to make more smoke than can be helped; fires should not be banked at night.

Householders who can use smokeless fuels should confine themselves to those fuels during periods of persistent fog. A mixture of coal and coke as already mentioned will effect some improvement.

Rubbish should not be burned, nor bonfires lit, while the fog lasts.

The general public should refrain from bringing motor cars into densely populated centres during a serious fog warning. In serious fog drivers of all motor vehicles should switch off engines whenever traffic is stationary, even temporarily.

Factories, commercial buildings, hotels, institutions, etc., should immediately put into effect action to watch and control all stoking of furnaces, and to prevent smoke.

Steps for mitigating the effects of "smog"

Less "smog" will find its way indoors, and rooms will be kept warmer, if draughts can be prevented.

Elderly people and those suffering from chronic chest and heart conditions, would be well advised to keep indoors and to rest as much as they can if the fog is very thick. Those who must go out will find that a closely-fitting simple gauze mask, or a woollen scarf wrapped round the mouth and nose, will give some relief, by filtering out some at least of the solid contents of the "smog".

16. The fullest co-operation of all sections of the public on the lines here indicated is essential.

17. It is emphasised that the measures proposed in this section are no more than palliatives to be put into force during the next few winters pending the results of permanent and satisfactory measures.

PART TWO

A MORE DETAILED TECHNICAL SURVEY

I. THE NATURE OF AIR POLLUTION

18. When coals and fuel oils are completely burned with air the principal gaseous products entering the chimney are carbon dioxide, nitrogen and excess air, water vapour, and sulphur dioxide. With coal most of the mineral matter is ordinarily left as ash or clinker, though a proportion—which varies with the type and grade of fuel and the conditions of firing—is carried forward as dust or grit with the chimney gases. If bituminous coal or oil is not completely burned the products include not only those already mentioned but also carbon monoxide, hydrocarbons and other combustible gases, and smoke in the form of soot and sticky tarry matter. Fuel oil, if not burnt properly, readily forms a very black smoke. The products of complete combustion of coke and anthracite are the same as those from coal and oil ; with imperfect combustion carbon monoxide also is produced, but there is little or no smoke. Low volatile coals (dry steam coals) behave in general similarly to coke, but may yield some smoke if burned imperfectly. Gas made at gas works for public supply is purified before distribution to remove all particles of tar, and nearly all of the sulphur compounds ; on complete combustion, which is easily achieved, it forms carbon dioxide and water vapour, with only very small quantities of oxides of sulphur.

19. Of the various products of combustion and partial combustion mentioned, the serious pollutants of the atmosphere are given below.

Table 1

Polluting substances from the combustion of coal and oil and their products

1. Solid	Particles of carbon or soot causing black smoke, and particles of coal, coke, smoke, and ash carried forward as dust and grit in the chimney gases.
2. Liquid or semi-solid carbonaceous matter.	Particles of tarry matter causing yellowish brown smoke.
3. Unburnt and partially burnt gases.	Hydrocarbons and carbon monoxide.
4. Sulphur oxides ...	Sulphur dioxide gas and sulphur trioxide mist, which with water give sulphurous and sulphuric acids.

Note : The polluting substances mentioned in items 1 and 2 are visible, and those in items 3 and 4 are invisible gases. There are smaller quantities of other serious pollutants including hydrochloric acid, oxides of nitrogen, and ammonium compounds.

20. The dispersion of polluting substances is affected by many factors, including the height of the chimney or other point of discharge, the velocity, temperature and amount of the discharge, the velocity and direction of the wind, the configuration of the ground and various other conditions. The larger particles settle more or less quickly to the ground ; the smaller particles and the gases mix with and remain in the atmosphere often for long periods and can be carried with the wind to great distances. A strong wind dilutes and disperses the pollutants at or near their source and prevents high local concentrations. The concentration of the pollutants gradually decreases downwind, as they become dispersed upwards and laterally by turbulent mixing with more air.

21. Carbonaceous particles arising from the incomplete combustion of coal are referred to as smoke. In general they are so small that they show little tendency to settle. Even under normal conditions in any large town the concentration of smoke at or near ground level may amount to over 1 oz. per million cubic feet. Such a concentration produces the dirty haze with which all town dwellers are only too familiar. It is not lethal, but in every way is undesirable and obnoxious. At times of bad fog the concentration in a large town rises much higher. During the London " smog " of December, 1952, a concentration as high as $4\frac{1}{2}$ ozs. per million cubic feet was recorded.

22. Sulphur dioxide is generally regarded as the most serious of the gaseous pollutants because of its harmful effects on structures, metals and other materials, on agriculture and, in all probability, on health. In winter, even in the absence of fog, the concentration of sulphur dioxide in the air of towns near ground level may be 17 to 35 parts per hundred million volumes of air ;* the normal summer concentrations are very much lower. The amount of sulphur dioxide discharged from chimneys is more than twice that of smoke (see Table 5), but at ground level the concentration of sulphur dioxide may be locally lower than that of smoke. This is partly because domestic smoke is discharged at a low level, whereas most of the sulphur dioxide is discharged from higher industrial chimneys and so is more easily dispersed ; and partly because it is removed from the air by absorption in water and by chemical reaction with buildings, materials and vegetation.

Air Pollution and Fog : The Black Spots

23. Fogs occur under known meteorological influences. They are natural phenomena and are uncontrollable by human effort. Except for reducing visibility on sea and land, they are relatively innocuous in themselves. It is " smog " or the combination of natural fog and pollution, that does most harm. Pollution thickens and contaminates fog. The presence of smoke in the atmosphere makes fogs more frequent and more persistent by providing nuclei for the formation of moist fog particles and by cutting off the sunshine, thereby retarding the natural processes of heating and evaporation.

24. The areas most susceptible to severe " smog " are therefore those which experience a high frequency of fog and in which urban and industrial density produce large amounts of pollution. These areas are indicated approximately on the map below (Appendix I, in back pocket). Within these areas are the black spots in which the gravest conditions recur and where the evils of air pollution are most pronounced and most persistent. It is here that the need for amelioration is most urgent.

II. THE MAIN SOURCES AND AMOUNTS OF POLLUTION

25. The inland consumption of solid fuel by classes of consumers in Great Britain in 1952 is shown in Tables 2 and 3. The quantity of raw coal used is given in column 2, of smokeless fuels made from some of that coal, in columns 3 to 6, and that of uncarbonised manufactured fuel, such as briquettes, in column 7, of Table 2.

Of the 204·7 million tons of coal, 53·1 million tons were carbonised to produce coke, gas, tar, motor spirit, fertilisers, and raw material for chemicals. The remainder, 151·6 million tons, were burned directly.

* The peak-concentration recorded during the London " smog " of December, 1952, was 134 parts per hundred million volumes of air.

Table 2

Inland consumption of solid fuel by classes of consumers (excluding Northern Ireland, Channel Islands and coastwise bunkers) in 1952

(Figures are in thousands of tons)

Class of consumer (1)	Total coal used (2) (*a*)	Smokeless Fuels				Other manufactured fuel (7)
		Anthracite (3)	Dry steam coal (4)	Coke (5)	Other carbonised fuels (6) (*b*)	
Industry (*c*)	43,528	1,049	857	16,680 (*d*)	8	200
Domestic (*e*)	36,941	751	990	2,930 (*f*)	589	400
Electricity (public supply)	35,670	557 (*i*)	977 (*j*)	—	12	—
Gas (coal carbonised) (public supply)	27,908 (*g*)	4	—	—	—	—
Coke ovens (coal carbonised)	25,224 (*g*)	1	—	—	—	—
Railways	13,935	8	218	150	—	200
Miscellaneous (*h*)	11,281	390	1,072	6,340	15	100
Collieries	10,226	86	—	—	—	—
Total	204,713	2,846	4,114	26,100	624	900

(*a*) The figures given in col. 2 include those in cols. 3 and 4.

(*b*) Includes "Phurnacite".

(*c*) Table 3—below—shows the distribution of coal and coke among the various groups of industries. The figures for industrial consumption relate to all establishments (about 26,000) consuming 100 tons or more of coal and/or coke per annum. There are 5,700 establishments which consume more than 1,000 tons of coal per annum accounting for 38½ million tons and 20,000 establishments consuming less than 1,000 tons per annum accounting for only 5 million tons of coal.

(*d*) Includes 11·3 million tons for blast furnaces.

(*e*) The domestic coal statistics include miners' coal as well as disposals by merchants to private residences, shops, offices, hotels, cinemas, institutions and the like and the smaller industrial consumers of solid fuel which are not separately programmed for their supplies. No precise separate estimate of consumption by private residences can be made from the available information, but it is thought that this is of the order of 35½ million tons of coal and non-carbonised briquettes, and 3 million tons of coke and other carbonised fuel.

(*f*) The domestic coke statistics cover a more limited field than those for coal in so far as they relate only to merchants' and producers' disposals to consumers of less than 10 tons per annum.

(*g*) Including the coal from which the coke in col. 5 is derived. The actual fuel burnt, based on an average thermal efficiency of 72 per cent. for gas works and 77 per cent. for coke ovens, is equivalent to approximately 7¾ million tons and 5¾ million tons of coal respectively.

(*h*) This includes coal for briquette works and low temperature carbonisation plants (cols. 6 and 7), waterworks, non-industrial establishments, Service Departments and other consumers not covered by statistical returns.

(*i*) This is mainly anthracite duff.

(*j*) This is mainly untreated duff and fines with high ash content.

Table 3

Industrial coal and coke consumption
Year 1952

Industry	Coal	Coke
	(Thousand tons)	
Iron and steel	7,827	12,857
Engineering	3,989	1,105
Others:		
Food, drink and tobacco	4,121	549
Chemical and allied trades	5,854	1,191
Textiles, leather and clothing	6,295	100
Paper, printing and stationery	3,406	36
Mines, quarries, etc.	1,018	329
Bricks, tiles, fireclay, other building materials, and contracting ...	3,592	205
China, earthenware and glass...	1,877	67
Cement	3,149	31
Timber trades	151	20
Other trades	2,249	190
Total	43,528	16,680

26. The inland distribution in 1952 of those petroleum products which can be a source of pollution is shown in Table 4.

Table 4

Inland distribution of petroleum products (excluding Northern Ireland, Channel Islands and coastwise bunkers) in 1952

Petroleum Product	Quantity
	(millions of tons)
Motor Spirit	5·32
Diesel Oil for road vehicles	1·16
Fuel Oil and other Gas/Diesel Oils:	
for burning	4·50
for power	0·81
Kerosine	1·38
	13·17

Pollution from solid fuel

27. Estimates of the amounts of polluting substances discharged into the air from the use of solid fuel are given in Table 5 below.

Table 5

Main uses of solid fuel and estimates of pollutants discharged from such uses in Great Britain in 1952

Type and use of fuel	Quantity of fuel (millions of tons per annum)	Pollutants discharged (millions of tons per annum) (*d*)		
		Smoke	Grit	Sulphur Dioxide
Raw Coal:				
For Domestic use	36·9	0·9	0·1	0·9
For Electricity Works	35·7	small	0·2	1·0
For Railways	13·9	0·4	0·1	0·4
For Industrial and miscellaneous uses (*a*)	65·1	0·8	0·2	1·8
For Coke Ovens (*c*)	25·2	small	small	0·1
For Gas Works (*c*)...	27·9	small	small	0·1
TOTAL	204·7			
Total consumption of coke (other than at Gas Works) (*b*)	26·1	nil	small	0·7
	TOTAL	2·1	0·6	5·0

(*a*) Includes general industry, collieries, patent fuel works, non-industrial establishments, waterworks, and the Service Departments.
(*b*) Includes 11·3 million tons for blast furnaces.
(*c*) Although over the whole country the smoke and grit discharged from gasworks and coke ovens is small, the pollution from certain types of plant and particularly from older coke oven plants can have a serious local concentration.
(*d*) In this table we have excluded carbon monoxide but refer to it in paragraphs 29, 32 and 33 of our report.

28. 36·9 million tons of coal, or between one-fifth and one-sixth of the inland consumption in 1952, were used in household and similar appliances. Of the total of 2·1 million tons of smoke emitted nearly one-half was from domestic appliances. The proportion is greater during the winter months. The total pollution by oxides of sulphur was about 5 million tons, and by grit about 0·6 million tons. One-fifth of the sulphur dioxide and one-sixth of the dust and grit came from domestic appliances, and one-fifth of the sulphur dioxide came from electricity works.

29. From the incomplete combustion of solid fuels, it is estimated that some 10 million tons of carbon monoxide are discharged per annum from domestic appliances. Other uses of coal and coke in industry yield about another 10 million tons, making a total of 20 million tons a year from solid fuels.

Pollution from oil

30. From the burning of 4·5 million tons of fuel and gas-diesel oils together with 0·6 million tons of creosote-pitch mixtures in 1952 there should be little smoke, given efficient combustion, but assuming an average sulphur content of 2-4 per cent. (1 per cent. in creosote-pitch), the burning of

the 5·1 million tons would result in about 0·3 million tons of sulphur dioxide being discharged with the chimney gases.

31. Diesel engines (road transport and others) use about 2 million tons of oil per year and produce from 20,000 to 40,000 tons of sulphur dioxide, and if in poor condition, emit clouds of dense smoke at ground level.

32. Some 5·3 million tons of motor spirit (including motor benzole) were used in road transport in 1952. The amount of sulphur dioxide produced from this source is negligible but the carbon monoxide content of the exhaust gases may be high and in total gives rise to some 4 million tons of carbon monoxide, which again is discharged at ground level. The total of 24 million tons of carbon monoxide seems likely to cause any harm only in "smog" conditions but knowledge is incomplete and investigation is required.

Total Pollution from solid fuel and oil

33. To summarise, the estimated quantities of the main pollutants discharged annually from the use of coal, oil and their products in Great Britain are as follows:

	Million tons
Smoke	2·1
Grit	0·6
Sulphur dioxide	5·3
Other acids (nitric and hydrochloric)	0·3
Carbon monoxide	24·0

These figures represent the total amounts discharged to the air; they do not indicate the distribution of the different pollutants, or the extent to which they are harmful.

The measurement of pollution

34. The next stage is to determine the concentration of these pollutants at or near ground level. Some substances settle out of the air quickly, others are dispersed and mix with the atmosphere. The degree of pollution is affected by the place, the time of year and the meteorological conditions. Without systematic records in a number of areas over several years it is impossible to gauge the magnitude of the problems to be solved, or to measure the effects of changing conditions or ameliorative action.

35. There is now a regular, though not yet by any means adequate, system of measuring and recording pollution. This work is undertaken under the guidance of the Atmospheric Pollution Research Committee of the Fuel Research Board of the Department of Scientific and Industrial Research, with whom some 160 local authorities and other co-operating bodies join in making regular measurements of pollution by standard methods. Monthly bulletins and reports are issued containing the results. Some 1,350 instruments are in use, measuring smoke, sulphur dioxide and deposited matter. These measurements are mainly made on a monthly basis and relatively few are made daily. A considerably greater number of daily records is required.

III. THE EFFECTS OF AIR POLLUTION

Health

36. The "smog" which covered Greater London on the five days 5th to 9th December, 1952, was of exceptional density and duration, though similar conditions may recur in London or in other towns. The London "smog" was accompanied by an immediate and sudden rise in both illness and

mortality. The number of deaths over and above those normally expected in the first three weeks of December indicate that some 4,000 people died as a result of the "smog". Deaths from bronchitis increased by about nine times during the week ended 13th December, and from pneumonia by nearly four times. Tables 6 and 7 show the weekly number of deaths during December according to age, and causes of death.

Deaths in the Administrative County of London weeks ending 6th, 13th, 20th, and 27th December, 1952, compared with average of previous 4 weeks

Table 6

Deaths divided according to age

Age	Average number of deaths registered in weeks ending 8th, 15th, 22nd, 29th November	Number of deaths registered in week ending			
		6th December	13th December	20th December	27th December
Weeks:					
0–4	20	16	28	19	12
4–52	8	12	26	15	11
Years:					
1–4	7	6	7	13	7
5–14	4	4	6	6	2
15–24	7	9	7	14	7
25–34	11	16	28	17	11
35–44	26	36	64	29	34
45–54	70	80	204	96	83
55–64	133	157	448	251	167
65–74	211	254	717	444	258
75 and over... ...	266	355	949	619	437
All ages	763	945	2,484	1,523	1,029

Table 7

Deaths divided according to cause

Cause	Average number of deaths registered in weeks ending 8th, 15th, 22nd, 29th November	Number of deaths registered in week ending			
		6th December	13th December	20th December	27th December
Pulmonary Tuberculosis	17	14	77	37	21
Lung Cancer	34	45	69	32	36
Heart Disease	226	273	707	389	272
High Blood Pressure ...	14	19	47	36	21
Other Diseases of Circulatory System	22	26	46	31	32
Influenza	2	2	24	9	6
Pneumonia	31	45	168	125	91
Bronchitis	51	76	704	396	184
Other Respiratory Diseases	6	9	52	21	13
Ill-defined Causes ...	20	25	79	35	37
All Other Causes ...	340	411	511	412	316
All Causes ...	763	945	2,484	1,523	1,029

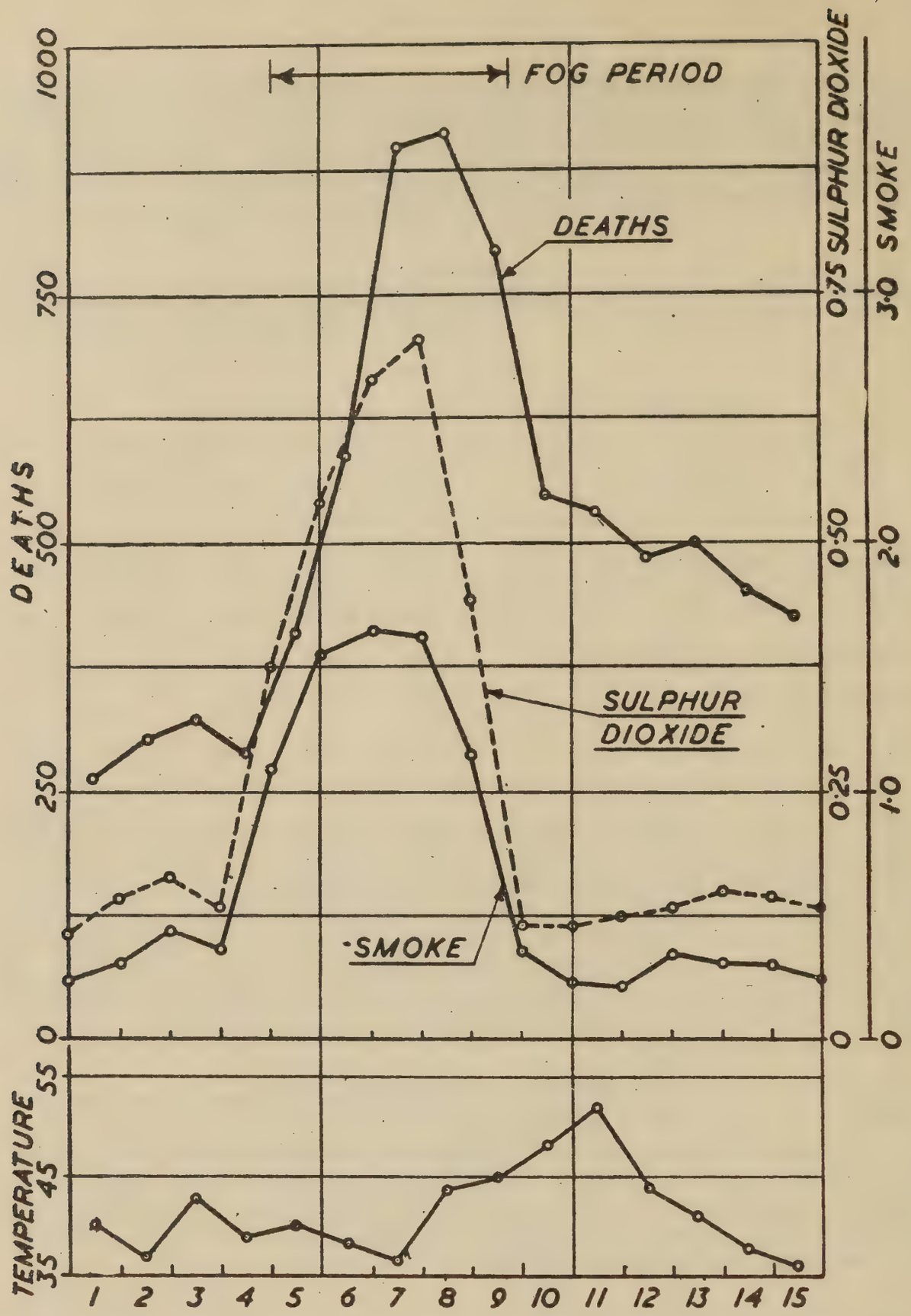
37. The London "smog" of December, 1952, resulted in a much larger increase in mortality than has been recorded in connection with previous London fogs. The comparative figures are as follows. In considering the earlier fogs it must be realised that the general death rate was then much higher than it is at present. The periods of fog start in week 2.

Table 8

Dates of Fog	Registered Deaths in London County Area				
	Weekly Totals				
	Week 1	Week 2	Week 3	Week 4	Week 5
Tuesday 9th–11th December, 1873	1,484	1,759	2,415	1,540	1,842
Monday 26th–29th January, 1880	1,900	2,200	3,376	2,495	2,016
Wednesday 28th–30th December, 1892 ...	1,606	1,830	2,509	2,503	2,101
Friday 26th November–1st December, 1948	846	779	1,019	944	891
Friday 5th–9th December, 1952	853	945	2,484	1,523	1,029

38. That the conditions during this period also produced increased illness is shown from the demands falling upon the hospitals. A report of the work of the Emergency Bed Service indicates that whereas on 1st January, 1951, at the height of the influenza epidemic, 293 applications for hospital beds were received, on 9th December, 1952, at the height of the fog period 492 applications were received and 390 were admitted to hospital. The increased sickness as seen by hospital applications was almost entirely due to respiratory disease, which was nearly quadrupled. The heart disease figures rose to three times the normal numbers.

39. We are not in a position, nor is there the evidence, to enable us to identify with any certainty the pollutants and the combination thereof which were responsible for the particularly harmful nature of the London "smog" of December, 1952. There is, however, a clear correlation between the pollution by smoke and sulphur dioxide, and the daily death rate in Greater London at that time. This is shown by the chart below which has been provided by the Fuel Research Station.

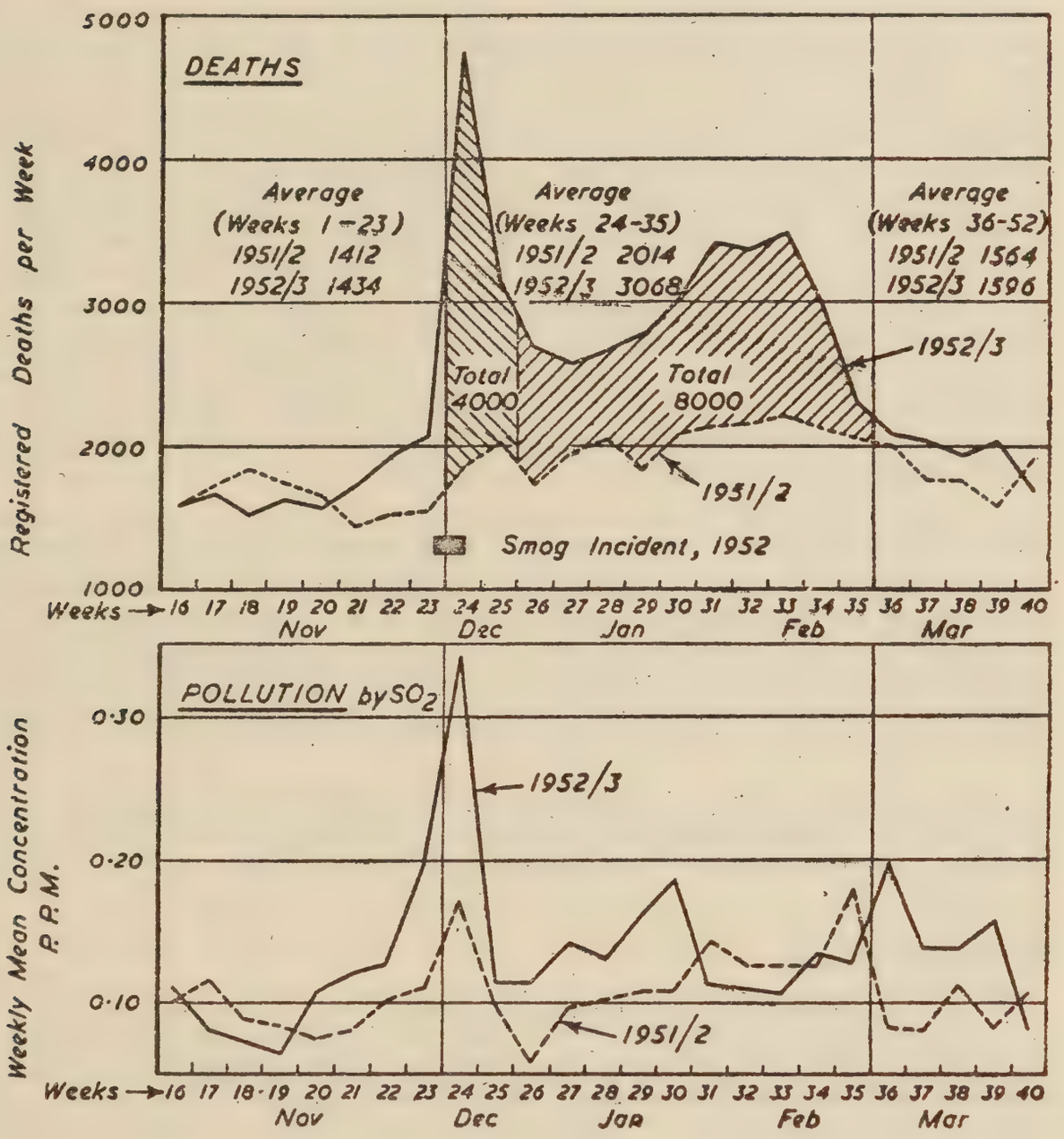


DEATHS, AIR POLLUTION AND TEMPERATURE DURING DECEMBER, 1952, IN GREATER LONDON (Population 8½ millions)

Units—Sulphur Dioxide	...	Concentration in parts per million parts of air* (mean of ten sites).
Smoke	... ...	Concentration in milligrams per cubic metre of air (mean of twelve sites).
Temperature	...	Degrees Fahrenheit (noon readings on Air Ministry roof).
Deaths	... ...	Total number occurring each day.

* NOTE: 1 part per million parts by volume of air equals 2·86 milligrams of Sulphur Dioxide per cubic metre of air at N.T.P.

40. We have been favoured with a copy of a recent paper which Dr. Wilkins, the Officer-in-Charge, Atmospheric Pollution Section of the Fuel Research Station, read on the 11th of this month before the Royal Sanitary Institute. In this there is included a chart which shows a continuing abnormal death rate in Greater London during the 2½ months following the "smog". We feel it desirable to reproduce this chart below, which we do with the permission of Dr. Wilkins and the Royal Sanitary Institute, although we have not as yet heard any medical evidence on the matter. Obviously this requires further, and close, investigation.



DEATHS AND AIR POLLUTION BY SULPHUR DIOXIDE IN GREATER LONDON, NOVEMBER, 1952, TO MARCH, 1953

Units—Sulphur Dioxide ... Concentration in parts per million parts of air.
Deaths ... ... Number registered each week.

The weeks are numbered consecutively 1–52 from July, 1952, to June, 1953. The period shown in the diagram (weeks 16–40) covers the period from mid-October to the beginning of April. The smog incident of 5th to 9th December, 1952, overlaps weeks Nos. 23 and 24.

41. What happened in London in December, 1952, emphasised the immediate danger to health from an abnormal concentration of air pollution. The effects on health and welfare of the continuing air pollution to which many town dwellers are regularly exposed are also serious. This is one of the most urgent problems to-day in the field of environmental hygiene. Pollution has long been thought to be associated with respiratory disease in both its acute and chronic forms, and it is possible that some carcinogenic substance in smoke plays a part in the causation of cancer of the lung. Pollution not only contaminates the air that people breathe; it deprives them of sunlight and makes their surroundings dirty and dark.

Material damage

42. In polluted atmospheres the soot and sulphurous and other acids materially damage the surfaces of buildings as well as marring their appearance. Limestone, some varieties of sandstone. mortar. and some kinds of roofing slate are all subject to direct attack with the formation of sulphates, the effects of which lead to blistering, scaling or pocking, and general disintegration of building stones and to delamination and decomposition of roofing slates. Bricks and those sandstones that are not themselves susceptible to direct attack by acids are liable to be damaged by the absorption of reaction products derived from neighbouring materials. In the course of time decorative features become obliterated and, by reason of scaling or general deterioration, an unsightly or even dangerous condition develops. The extent of the damage is evident in many of our oldest and most treasured buildings, among them Westminster Abbey. But the effects are not confined to ancient buildings: they can be seen in buildings of every date, including quite recent ones.

43. Many metals are subject to atmospheric corrosion in polluted atmospheres. Iron and steel rust rapidly when exposed to sulphur acids, and copper, aluminium and brass are also subject to attack. It is known that the rate of corrosion increases with increase in the concentration of sulphur dioxide in the atmosphere. Leather, wool, cotton, furnishing materials and works of art are all directly and seriously harmed by acids in the atmosphere. Smoke and sulphur dioxide are harmful to plants and may have serious effects on agriculture in certain areas.

This is no more than an indication of the destructive nature of air pollution, and the details could be elaborated at much greater length; but it is clear that it entails a continuous and costly drain on our material resources.

The economic cost

44. The economic loss borne by the nation year after year as the result of air pollution is very great. The direct cost includes the heavy recurring expenditure by property-owners, householders and individuals on washing, cleaning, repairing and renewing soiled or damaged buildings, materials, clothing and other articles. All the labour, materials and energy employed in extra cleaning are totally unproductive. Indirect items are the cost of the damage to health and its consequences, the extra cost of artificial lighting due to the reduction of daylight, and the loss of efficiency of all forms of transport in town "smogs". A major cost of pollution is the fuel that is wasted in producing smoke and unburnt gases through incomplete combustion. The fuel so wasted is in the region of 5 to 10 million tons a year.

45. It is clearly impossible without much more study to do more than guess at what the cost may be, but recent estimates of £100–£150 million per

annum may not be far from the mark. This is a matter on which we intend to seek evidence. But it is clear to us even now that the expenditure of many millions of pounds a year in eliminating smoke would be a most profitable national investment.

IV. THE LEGISLATIVE PROVISIONS

Smoke

46. The main statutory provisions now in force for the control of smoke are contained in the Public Health Act, 1936, the Public Health (London) Act, 1936, and the Public Health (Scotland) Acts, 1897 to 1939. The authorities responsible for enforcing the Acts are, in London, the London County Council and the Metropolitan Borough Councils; in the rest of England and Wales, the Councils of County Boroughs, Boroughs, and County Districts; and in Scotland, Town Councils and County Councils.

There are also in Scotland the Smoke Nuisance (Scotland) Acts, 1857 and 1865, which apply to burghs with a population of 2,000 and more; and the Burgh Police (Scotland) Acts, 1892 and 1903, administered by all town councils except those of Edinburgh, Glasgow, Dundee, Aberdeen, and Greenock, who have similar powers under local Acts.

47. The Public Health Act, 1936, constitutes as statutory nuisances any installation for the combustion of fuel which is used in any manufacturing or trade process and which does not so far as practicable prevent the emission of smoke; and any chimney (except a chimney of a private house) emitting smoke in such quantity as to be a nuisance. Where a notice served by a local authority requiring the abatement of a nuisance is not complied with, proceedings may be taken before a court of summary jurisdiction. The court can impose a fine of up to £50 and may make an order for the abatement, or prohibition of recurrence, of the nuisance.

It is, however, a defence in any proceedings for discharging smoke, other than black smoke, to show that the best practicable means for preventing the nuisance have been used. "Best practicable means" refers both to the provision and maintenance of adequate plant and to the manner in which the plant is used.

The provisions of the Scottish and London Acts are substantially similar. The expression "smoke" is defined in the Public Health Act, 1936, as including "soot, ash, grit or gritty particles". There is no definition of "smoke" in Scottish public general legislation, and difficulties have as a result been met in attempting to deal with complaints of grit from factory chimneys.

48. The English Acts, and in Scotland the Burgh Police Acts, contain a saving clause for certain industrial processes. The provisions of the Acts may not be applied so as to obstruct or interfere with the working of mines or with a number of operations in iron and steel works.

49. Under the Public Health Act, 1936, local authorities may make byelaws, subject to confirmation by the Minister of Housing and Local Government, regulating the emission of smoke of such colour, density, or content, as may be prescribed by the byelaws. Such byelaws do not apply to private houses. The byelaws usually make it an offence to discharge black smoke for two minutes in the aggregate within a continuous period of thirty minutes. 229 local authorities in England have so far made such byelaws, all of them dealing only with black smoke.

Dust and Effluvia

50. The Public Health Act, 1936, constitutes as a statutory nuisance any dust or effluvia caused by any trade, business, manufacture, or process and which is injurious or dangerous to the health of, or a nuisance to, the inhabitants of the neighbourhood.

The method of enforcement is that described in paragraph 47 above. The Scottish and London Acts contain similar provisions, dealing with effluvia.

There is again a "best practicable means of prevention" defence.

Railways

51. The Railway Clauses Consolidation Act, 1845, and the Regulation of Railways Act, 1868, and the corresponding Scottish Acts, provide that every railway locomotive steam engine shall be constructed on the principle of consuming, and so as to consume, its own smoke and make it an offence if any locomotive, through default by the Company or its servants, fails to consume its own smoke. No particular body is invested with the duty of enforcing these Acts. In England and Wales, any person (or corporate body) may complain to the courts. In Scotland the complaint would be made to the Procurator-Fiscal, who would decide whether to prosecute.

Coal Mine Refuse

52. Under the Public Health (Coal Mines Refuse) Act, 1939, and the corresponding Scottish Act, local authorities can deal with, as statutory nuisances, any deposit of refuse from a coal mine where there is reasonable cause to believe that spontaneous combustion is likely to occur. It is a good defence to show that the best practicable means are being used to prevent an outbreak of fire.

Road Traffic Acts, 1930–1947

53. These Acts empower the Minister of Transport to make regulations as to the construction and equipment of motor vehicles and in particular to the consumption of smoke and emission of visible vapour, sparks, ashes and grit. The Motor Vehicles (Construction and Use) Regulations, 1951,* in effect require every motor vehicle to be constructed, maintained and operated in such a way as to prevent avoidable emission of smoke or visible vapour. Failure to comply with these Regulations is an offence under the Road Traffic Acts, 1930–1947. Under these Acts, action lies with the Police.

The Alkali, etc., Works Regulation Act, 1906

54. The Act, which applies with suitable modifications to Scotland as well as England, refers to pollution from certain chemical and industrial processes rather than from the combustion of fuel. It is, however, worth mentioning since the Act is administered directly by the Alkali Inspectors appointed by the Minister of Housing and Local Government and the Secretary of State for Scotland. In England and Wales local authorities may not, without the consent of the Minister, institute proceedings under the Public Health Acts if action can be taken under this Act.

Local Acts

55. There is no provision in general legislation for declaring "smokeless zones", but 17 local authorities (15 in England and two in Scotland) have obtained special powers for the purpose, by local Acts. The Acts empower the authority, in some cases by an order requiring confirmation by the Minister of Housing and Local Government or the Secretary of State for

* S.I. 2101 of 1951.

Scotland, to define areas in which the emission of smoke is either prohibited or strictly regulated. These powers have so far been used in two cases (Coventry and Manchester) which are referred to in more detail later in this Report.

56. A number of local Acts also contain what is sometimes known as the "prior approval" clause, which makes it an offence to instal a furnace unless it is, so far as practicable, capable of being operated without emitting smoke. The person proposing to instal a furnace may if he wishes seek the local authority's approval to the installation in advance, and no proceedings can then be taken under the section if the authority have either approved the furnace or failed to disapprove it within a specified period.

V. PREVENTIVE MEASURES

57. The cleaning of coal before despatch from the coal fields gets rid of much of the shale and some of the sulphur compounds, and this reduces the amount of grit and sulphur dioxide discharged with the flue gases when the coal is subsequently burnt. The total amount of coal cleaned per year rose from 90·5 million tons to 113·7 million tons between 1947 and 1952.

58. The conversion, by efficient modern processes, of bituminous coal into coke and smokeless fuel on the one hand, and into gas and electricity on the other hand are on our present information the only means of eliminating air pollution by domestic smoke. The following table shows the trend in this direction. From our point of view it is in the right direction but not fast enough. We are enquiring how it can be expedited.

Table 9

	Million tons		
	1938	1948	1952
Coal used at—			
public supply electricity generating stations ...	14·9	28·8	35·7
public supply gas works	19·1	24·6	27·9
coke ovens	19·1	22·3	25·2
low temperature carbonisation works	0·5	0·4	0·5
Total	53·6	76·1	89·3

Domestic

59. The domestic fire burning bituminous coal is in the aggregate the principal contributor to air pollution by smoke. There are in regular use about 12 million old-fashioned grates, very few of which use smokeless fuel. The replacement of bituminous coal by smokeless solid fuel presents two difficulties: the supply of the latter is insufficient, and coke—which forms the greater part of present smokeless fuel supplies—cannot be burnt satisfactorily by itself in most of the old-fashioned open grates still used in most houses. We intend to hear evidence as to how these difficulties can best be overcome and whether it is possible in the meantime for smokeless fuels to be reserved for the worst "smog" areas. In the meantime it is obvious that our available coals are not being used in the most appropriate way; high volatile coals are supplied for domestic use and much of the low volatile coals, for instance from South Wales, are used industrially.

60. In recent years progress has been made in the development of domestic heating appliances, including improved types of open fires, which will burn coke efficiently and well. A list of tested and recommended appliances is issued by the Coal Utilisation Council; this list includes all the appliances recommended by the Ministry of Fuel and Power. Since 1948 it has been a condition of approval of tenders for new local authority houses that the main appliances shall be selected from this list. The Coke Department of the Gas Council also issues an independent list of appliances approved by the gas industry for burning coke. About four million approved appliances have been delivered to distributors in the home market since 1947. These appliances give their best performance with smokeless fuels, for example with coke the efficiency is about one-third greater than with bituminous coal. Many of them are an improvement on older appliances even when burning bituminous coal. It seems probable that the increased use of such appliances and the provision of smokeless fuels are the best means at present of reducing smoke from domestic chimneys and we propose to invite evidence as to how progress in this direction can be greatly accelerated.

Central and district heating

61. Blocks of offices and other large buildings are in many instances provided with space heating and hot water from large central boilers in which it is possible to burn bituminous coal with relatively high efficiency and with little smoke. An increase of this type of heating, and its extension to district heating where the circumstances are suitable, are in the interests of both fuel efficiency and smoke abatement. This principle has been extended to flats in grouped blocks with a common heating service and to some housing estates. Experience, however, indicates that central heating of domestic households from a common service uses more coal per household than is used in individual households not centrally heated both because central heating permits a higher standard than is otherwise demanded and because the cost is met by a fixed annual charge—irrespective of usage. To charge in proportion to use means some form of heat metering and it has not yet been found possible to devise a satisfactory meter for small individual households, that could be marketed, installed, serviced and read at an economic cost. When this problem is solved the extension of district heating to blocks of flats and housing estates should be more economical than it is at present. The provision of both heat and electricity from single installations has been extensively studied, and a large-scale installation is now in trial operation in the Pimlico housing estate in London. These are however, long-term rather than immediate remedies; they can have but little effect on the already existing densely built up areas.

Use of gas and electricity

62. Greater use of gas and electricity in place of bituminous coal obviously reduces smoke but for reasons of cost and availability it is likely that gas and electricity cannot under present conditions displace solid fuel in meeting the major part of the main heating load in the winter.

Industrial

Improved efficiency

63. It has long been recognised that efficiency in the use of bituminous coal by industry falls far short of what is desirable and practicable, and to a large extent fuel efficiency and smoke abatement are two aspects of the same problem. Since 1941 the Ministry of Fuel and Power has provided a fuel efficiency advisory service to Industry. The core of this work

now is the making of quantitative fuel and power surveys at individual works. Each survey report makes recommendations for reducing the losses and estimates the fuel savings that should result. The order of possible savings at the works so far surveyed is 16–25 per cent. The effect of improving efficiency of combustion and of use of steam is to reduce the amount of fuel used to provide a given service and to lessen the pollution caused per ton of the reduced fuel used—a double benefit.

64. Some part of this saving can be achieved by improved boiler-house operation and supervision, better maintenance of plant, and improved insulation of hot pipes; but the rest of the saving can be obtained only by replacing obsolescent equipment. Modernising or replacing such plant requires capital. To encourage industry to invest capital in fuel efficiency where it is needed the Government have introduced a loan scheme whereby capital for approved fuel-saving projects can be obtained on favourable terms. There has been some response to this scheme since it was started in June, 1953, but so far it is too small. Arrangements have now been made for the transfer of the Fuel Efficiency service to a new fuel efficiency company sponsored by the British Productivity Council; and we shall discuss with this new Company the means of securing much more rapid results.

65. In 1942 courses for the training of boiler-house staff were started, and since then more than 46,000 men have attended classes in fuel efficiency subjects. Courses in boiler-house practice suitable for stokers and boiler attendants, based on syllabuses prepared by the City and Guilds of London Institute, are now available at technical schools and colleges throughout the country. A recent development has been the introduction of a new course and examination leading to the award of a Boiler Operators Certificate by the City and Guilds of London Institute.

66. The foregoing deals primarily with industry, but what has been said is also applicable to commercial premises and to schools, offices, hospitals, and other institutions. We understand that the fuel and power industries have developed special measures in their own fields for promoting combustion efficiency and reducing air pollution.

Smoke Prevention

67. With large modern boiler installations such as those at electricity generating stations and modern factories there is no difficulty in burning any type of coal with little or no smoke provided the equipment is kept in order and properly operated. With large numbers of hand-fired boilers burning bituminous coal at numerous industrial works and institutions, not enough is done or attempted to avoid the emission of smoke, especially for the period immediately after stoking. The Fuel Research Station have devised firedoors which admit extra secondary air when smoky volatile matter is being produced; these not only eliminate smoke but on full-scale tests have shown a reduction of five or six per cent. in the quantity of coal used for the same amount of steam raised. These doors are produced by several manufacturers and many hundreds have been fitted to industrial boilers. But this represents only a small proportion of the 40-50,000 hand-fired boilers in use in industry and which it is believed consume about 20 million tons of coal per year. There are only a few types of industrial processes using coal where satisfactory methods of avoiding the emission of smoke without detriment to the quality of the product have not yet been developed. This and cognate problems relating to particular industries are also being investigated by the Fuel Research Station. But enough is known to make a major contribution to industrial smoke prevention, if generally applied.

68. The carbonising industry (Gas Area Boards, National Coal Board, and privately owned coke ovens) consumed 53 million tons of coal in 1952. Modern carbonising plant, if efficiently operated, need not make a serious contribution by smoke to atmospheric pollution, although some smoke is emitted during the charging of coke ovens and certain types of gas retorts. Improvements have been obtained by incorporating in the newer coke ovens a double gas main and by charging the ovens when connected to the gas mains, but careful operation remains essential.

69. The National Coal Board consumed 10 million tons of coal at collieries in 1952. Much of the boiler plant in which this coal was consumed is old and often is worked in circumstances conducive to excessive smoke. We are informed that the Board have a substantial programme under way for improving operating conditions of existing plant and training boiler staff, and also for replacing obsolete plant, and installing mechanical stokers in existing plant.

70. British Railways have, we understand, their own fuel efficiency organisation. The overall average thermal efficiency of steam locomotives at present is only five or six per cent. Much of the smoke from railways comes from shunting engines and stationary locomotives. The programme for replacing shunting engines by diesel engines should yield a progressive improvement but we do not know how rapid the change will be. We believe that experiments have been undertaken in the pre-steaming of locomotives with a view to reducing smoke during firing up. We have no specific information about this. Electrification of the railways increases thermal efficiency to between 10 and 15 per cent. and obviously saves fuel and reduces air pollution. But since it is uneconomic except where the density of traffic is high, this can have only a limited effect on our problem. We shall take evidence as to whether the exclusion of steam locomotives from densely built up areas is practicable.

71. The gases entering the flues of industrial boilers and other furnaces fired with solid fuel carry appreciable quantities of dust and grit including some carbonaceous material, particularly where furnaces are fired with pulverised fuel, or are operated with forced draught. Most of this grit can be removed by grit-arrestors such as those installed at all electricity generating stations except a few small obsolete ones. Modern designs of cyclone extractors remove most of the larger particles and can achieve an overall efficiency of grit extraction of the order of 80 per cent. Well designed electrostatic precipitators can take out the smaller particles and bring up the efficiencies to over 90 per cent.

Every Statutory Consent which the Ministry of Fuel and Power now gives under the Electric Lighting Act, 1909, as amended by the Electricity Act, 1947, for the erection or extension of generating stations carries a condition that the most up-to-date method of arresting grit shall be used.

Sulphur Dioxide

72. Although the sulphur content of British coals varies considerably, it has been estimated that as an overall average British coals and cokes contain about 1·5 per cent. of sulphur. Residual fuel oils from petroleum generally contain from 2 to 4 per cent. When the fuel is burnt, whether in industrial or domestic appliances, most of the sulphur is also burnt, being converted to twice its weight of sulphur dioxide, a gas of acidic properties which is discharged with the chimney gases. The concentration of sulphur dioxide in the flue gases from coal is ordinarily no more than about 0·1 per cent. by volume. A large power station using 2,000 tons of coal a day discharges

60 tons of sulphur dioxide per day mixed with nearly 1,000 million cubic feet of flue gases. The treatment of these large volumes of gases for the removal of sulphur dioxide is no simple matter and is expensive.

73. The only processes developed on a full scale have been at the power stations at Battersea and Fulham in London. The Battersea process uses water from the Thames, with the addition of some chalk, as the washing medium. We are informed that some 35 tons of water are required per ton of coal burnt and that up to 85 per cent. of the sulphur dioxide in the flue gases can be removed. The process operated before the war but was suspended during the war; although it has been reinstated, maintenance difficulties have been recurrent and have prevented its application to all of the flue gases produced at one time.

A somewhat similar process is being used at the Bankside power station in London where oil containing 3 to 4 per cent. of sulphur is being burnt.

74. A process was in operation before the war at the Fulham power station in which a closed circulating system using water with considerable additions of chalk was adopted. This process has not been reinstated since it was abandoned during the war.

75. With all the above processes the cost per ton of fuel is considerable, nor do they provide any marketable product. They also lower the temperature of the gases and therefore the "effective" height of the chimney for dispersing the gases, and it has been suggested that, at least for the immediate neighbourhood of the station, the disadvantage of reduced dispersion cancels out any gain from the emission of cleaner gas, but so far it has not been possible to prove or disprove this. Experimental work on a process using ammonia liquor as its washing medium has been undertaken by the Fulham power station and more recently by the Fuel Research Station on a pilot scale. The final products are ammonium sulphate and sulphur. We propose to hear evidence on this important question of processes for the removal of sulphur dioxide discharged with chimney gases, their usefulness, economics and practicability from every point of view, including the economics of producing by one or other of them a marketable end product.

Enforcement

76. Vigorous and continuous action along the lines indicated in paragraphs 57–75 supported by a strict application of the existing law regarding smoke emission, would at once largely reduce the pollution caused by domestic and industrial smoke. We propose to consider whether the present legal powers could be more effectively used and whether they need strengthening.

77. The "smokeless zone" provisions of some local Acts, unlike the smoke provisions of the Public Health Acts, apply to domestic as well as industrial smoke. The effect of the provisions of the Acts where in force, is to prohibit the emission of smoke from any premises (unless exceptions are specified) in certain areas which are defined either by the Acts themselves or by orders made by the local authorities and confirmed by the Minister of Housing and Local Government or the Secretary of State for Scotland.

78. Of the 17 local authorities which have obtained special powers for the purpose, only two have so far put statutory smokeless zones into operation—Coventry and Manchester. The zone at Coventry became effective on 1st March, 1951, and covers some 30 acres in the central part of the city which were badly bombed during the war and were due for redevelopment. There were only two dwelling-houses in the area. The Manchester zone was

established on 1st May, 1952. It covers about 104 acres in the central area, which again is largely non-residential. In many atmospheric conditions the effect of the Manchester smokeless zone is, we understand, very noticeable. It is an indication of what is possible.

79. In the United States large smokeless areas have been achieved at St. Louis, Pittsburg and elsewhere and without doubt are effective. The principle of smokeless zones has naturally, therefore, attracted much attention and is widely regarded as a simple and easy solution of the "smog" problem. Its rapid extension in this country is, however, subject to practical limitations. To have any material effect the zones must be large; if they are small they will not in fact be "smokeless" since they will receive smoke from surrounding areas. The prohibition of smoke in an area presupposes that all the fuel that is burnt, whether in industrial or domestic premises, can be burnt without smoke, that is to say that every building will be equipped with the right kinds of appliances and that sufficient smokeless fuels will be available. While supplies of the latter are limited, their allocation only to smokeless zones would be at the expense of other areas. This suggests that any extension of smokeless zones, if they are to have the best results, should be carefully planned according to the needs of different areas. A smokeless zone may be achieved with less difficulty in an area of new development, but in the case of existing property it is likely to entail extensive conversions of plant and equipment and a radical change in traditional methods of heating. The establishment of smokeless zones must, under present conditions, involve increased expenditure and restrictions on the use of fuels whether in regard to industrial or domestic fires.

The practicability and the economics involved in the extensive development of smokeless zones are matters which we are investigating.

VI. SUMMARY OF PART TWO

80. The most serious immediate problem in regard to air pollution is that which arises from the combustion of fuel (coal, oil and other products) in large towns [1]*.

The effects are most serious when natural weather conditions allow the pollution to accumulate, and when natural fog is turned into "smog" [23].

The areas in which this is most likely to happen are known. These are the black spots where the need for prevention is most urgent [24].

The London "smog" of December, 1952, which resulted in some 4,000 deaths, emphasised that heavy concentrations of pollution can be lethal [36–40].

The pollution that occurs regularly in many large towns is also a menace to health, and has serious social, material and economic consequences [41–44].

The material cost borne by the community every year is substantial; it may amount (so far as it is measurable in money) to more than £100 million a year, apart from the cost in wasted fuel which smoke represents [45].

The chief pollutants are smoke, sulphur dioxide, carbon monoxide, and grit. The domestic fire is the biggest single *smoke* producer. In ratio to the coal burnt it produces twice as much smoke as industry, and discharges it at a lower level [27, 28, 33].

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* These figures refer to the numbered paragraphs in the Report.

Three-fifths of the *sulphur dioxide* comes from industrial sources, one-fifth from electricity generating stations, and one-fifth from domestic consumers [28].

Carbon monoxide is produced in about equal proportions from domestic and other sources, but about one-sixth of the total comes from motor vehicle exhausts. Under certain conditions this may cause relatively high local concentration at or near ground level [29, 32].

Grit, although the total weight emitted is only about one-quarter that of smoke, is produced from a large number of different sources in substantial quantities [27, 28].

The Acts in force for the control of pollution are designed to secure that the best practicable means of prevention are used. Except for the " smokeless zone " provisions in local Acts they are aimed at pollution from industrial and not domestic sources [46–56].

The problem of reducing pollution, and of creating real smokeless zones, is largely that of the practical means. Short of stopping people from lighting fires and bringing industry to a standstill, prevention can be enforced only if there is the necessary technical " know-how ", the will and means of applying it, and the appropriate fuel [76–79].

The measures which have been or are now being taken to tackle the problem of pollution may be summarised briefly:—

(1) The conversion of bituminous coal into coke, gas and electricity [58].

(2) The use of smokeless fuels for domestic purposes in place of bituminous coal [59].

(3) The replacement of old-fashioned domestic grates by improved appliances in which smokeless solid fuels, and if necessary bituminous coal, can be burnt with appreciably greater efficiency [60].

(4) The extension, where economic, of central or district heating, whereby blocks or groups of buildings are heated from a single smokelessly fired boiler [61].

(5) The promotion of greater fuel efficiency in industry, both by more competent use of existing equipment and by the modernisation of present equipment or the installation of new equipment where it is needed [63–70].

(6) The use of efficient grit-arresting plant for furnaces fired by pulverised fuel or operated by forced draught [71].

(7) The cleaning of coal at the coal fields in order to remove shale and some of the sulphur compounds [57].

(8) Research and development work on practicable methods of removing sulphur dioxide from the flue gases of power stations and other large boiler plants [72–75].

81. This preliminary Report has outlined the main features of the problem of air pollution as it exists to-day. The causes and remedies of pollution by smoke are known ; the problem is one of practicability and economics, and of the education of the whole community. *Complete* cure of both solid and gaseous pollution, if indeed it be ever attainable, is bound to take many years, but means of averting at least the worst evils of *air pollution by smoke and grit* are within practicable reach. It is simply a question of balancing the cost and inconvenience of enforcing a more efficient and scientific use of our fuels against all the advantages to be obtained in health, convenience and economy from a clear atmosphere. This problem, with all that is involved in a real attack on the menace of air pollution, is one which must

be faced. We now propose to embark upon the detailed study of the practical difficulties which we have indicated in this interim report. But we feel bound to point out that such work will be merely of academic interest and can lead to no material improvement unless there is general acceptance of the fact that the cure will require heavy expenditure and full co-operation of all persons and all interests.

Sources of Tables

The information contained in the Tables was supplied as follows:—

Department of Scientific and Industrial Research—Fuel Research Station.

Tables 1 and 5, and charts in paras. 39 and 40.

Ministry of Fuel and Power.

Tables 2, 3, 4 and 9.

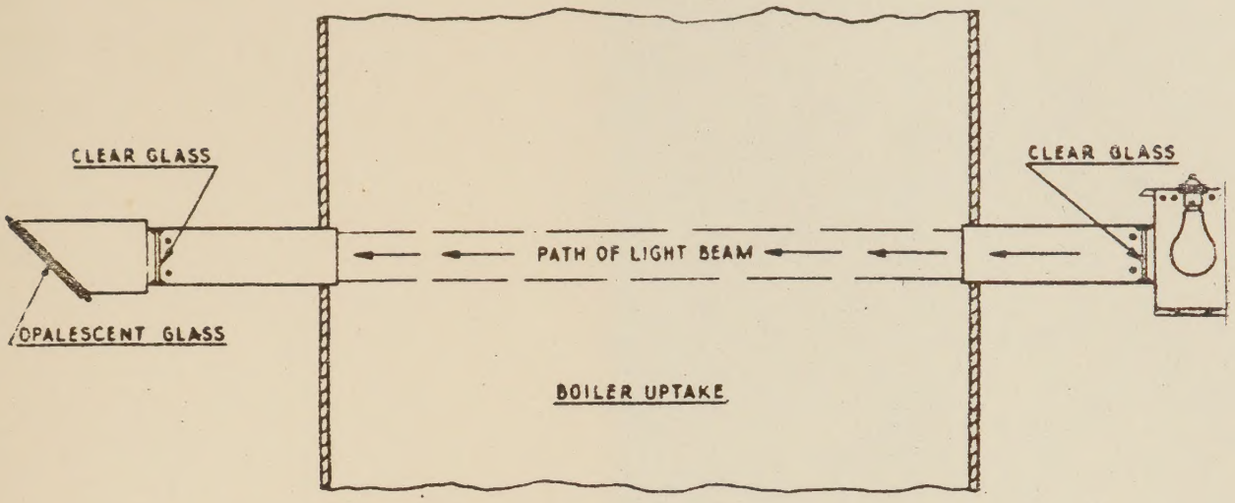
General Register Office.

Tables 6, 7, 8.

APPENDIX I

MAP; AIR POLLUTION ... ... In pocket

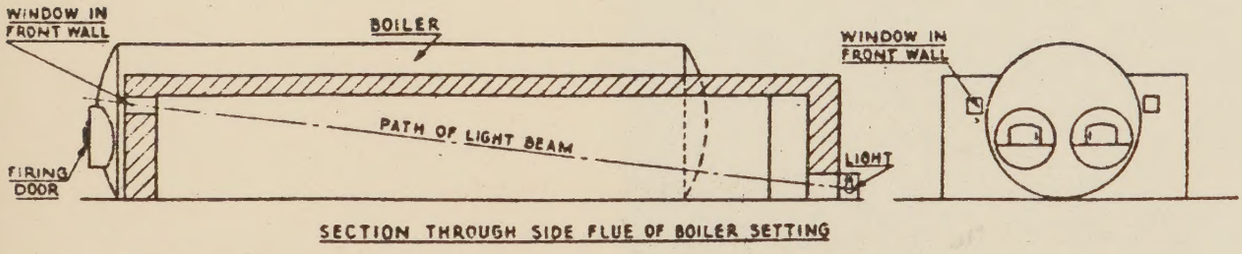
APPENDIX II



SMOKE INDICATOR

Suitable for Flues more than 4 feet wide. Degree of illumination of Opalescent Glass is a measure of the density of the smoke.

APPENDIX III



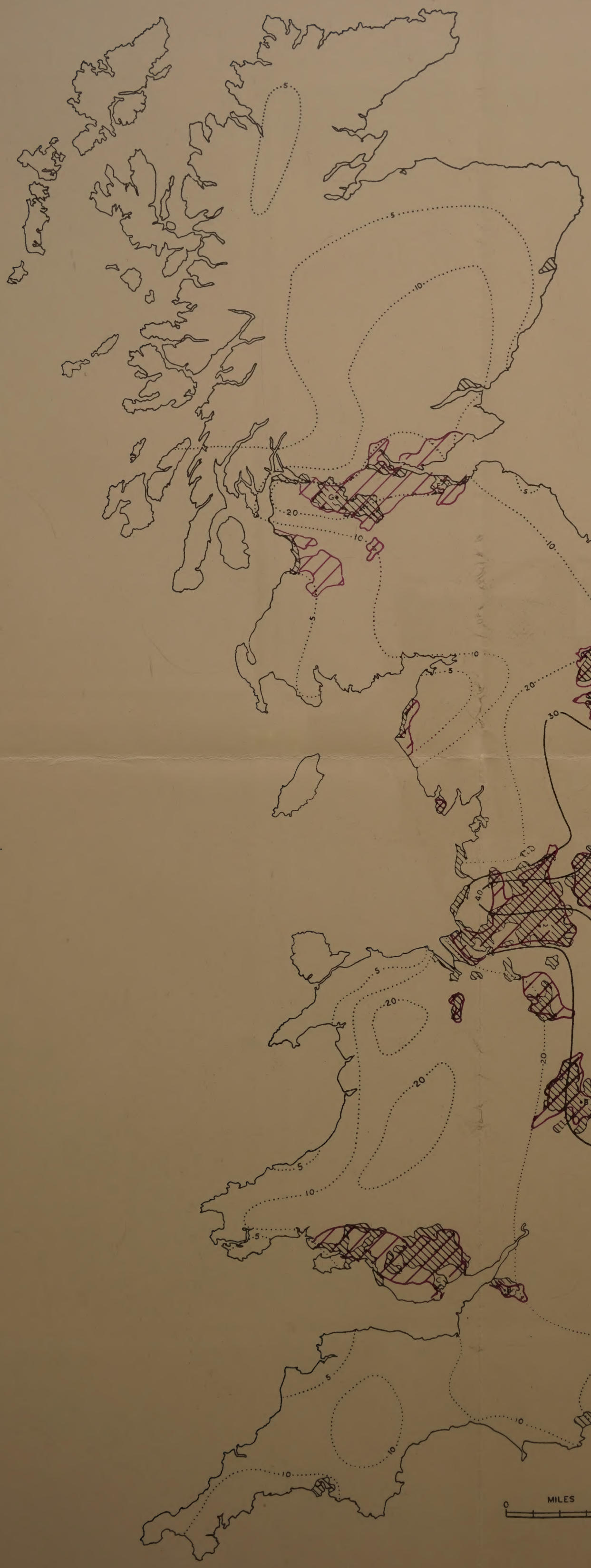
SMOKE INDICATOR FOR LANCASHIRE BOILER

Suitable where there is free access to the rear wall of the boiler setting. Openings are cut in the front and rear walls and fitted with glass windows. A light placed at the rear openings is visible through the front window when no smoke is made.

Medium smoke causes the light to become invisible.

5947. D1884. Wt. 1380. 5/59 S(P&D)L.

AIR POLLUTION



Main Industrial Areas

Densely Populated Areas
(about 1,000 persons and over per square mile)

Frequency of fog: 30 occasions and over

Under 30 occasions

(average number of occasions annually with less than 1,100 yards visibility at 9 a.m. 1934-43)

(Reproduced from the Climatological Atlas of the British Isles, H.M. Stationery Office 1952)

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